

Effect of Attenuation Models on Communication System Design

F. I. Shimabukuro
The Aerospace Corporation

Introduction

The atmosphere has a significant impact on the design of a global communication system operating at 20 GHz. The system under consideration has a total atmospheric link attenuation budget that is less than 6 dB. For this relatively small link margin, rain, cloud, and molecular attenuation have to be taken into account. For an assessment of system performance on a global basis, attenuation models are utilized. There is concern whether current models can adequately describe the atmospheric effects such that a system planner can properly allocate his resources for superior overall system performance. The atmospheric attenuation as predicted by models will be examined.

Rain effects

To assess the impact of rain on overall system performance rain attenuation models are utilized. Figure 1 shows the predicted exceedance attenuation for two rain models, the CCIR and the Global at mid latitudes. For comparison similar rain regions, the K region for the CCIR model, and the D2 region for the Global are used. For the assumptions shown for the ground terminal, 40 degrees latitude, sea level, 30 degrees elevation, using circular polarization, there is reasonable agreement between the models. There is about a 1 dB difference at the 2 per cent level. The correspondence is not surprising, because these models have been tailored to fit the same available attenuation measurements, for which there is an ample data base for this climate region.

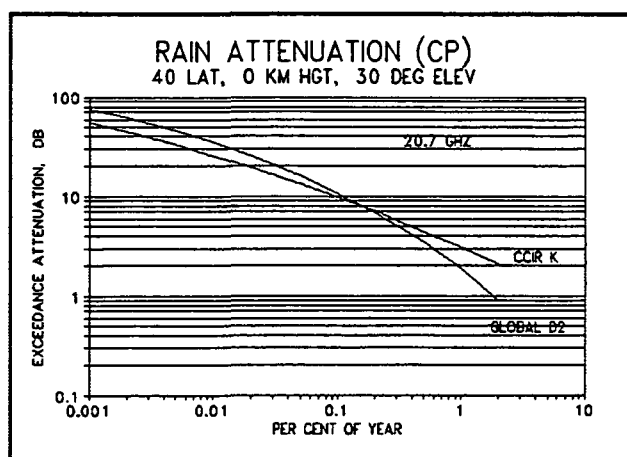


Fig. 1. Rain attenuation for CCIR K and Global D2 regions.

At 20 GHz, system performance would be most degraded by rain in tropical regions. In Fig. 2, exceedance attenuations are shown for the CCIR P and Global H climate regions. In this case we see a large discrepancy in the predictions. For example, for the assumed conditions here, there is a 30 dB difference at the 0.1 % level, and a 13 dB difference at the 0.5 % level. And these differences widen further at lower elevation angles. There are indications that even the CCIR model may overestimate the rain attenuation in tropical zones. The designer might feel a bit uneasy in planning for system operation in the tropical rain regions. Clearly, more rain data is needed in these areas. The NAPEX and ACTS programs will resolve some of these issues, but it would be more comforting if at least one of the ACTS terminals were in the tropics. In addition to the annual rain statistics the system planner is also interested in performance in the "worst" month. Suppose the rain margin is 4 dB. For region H, at an elevation angle of 30 degrees, the Global model predicts a link availability of 97.2 per cent. In the worst month, using the "average" CCIR Q value, the link availability decreases to 93 per cent. It is not clear how the Q statistics vary for different global regions, and these data would greatly benefit system planning.

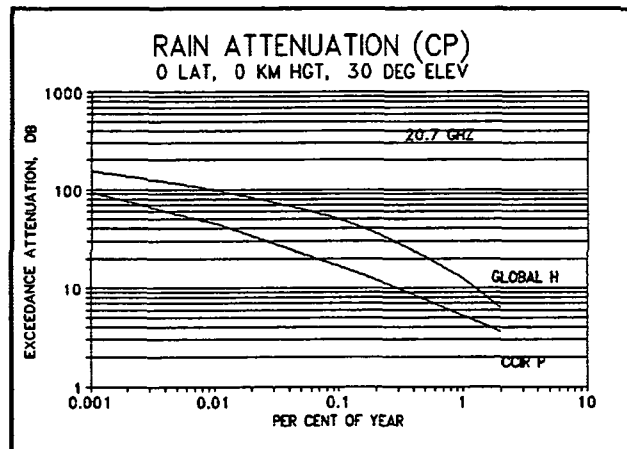


Fig. 2. Rain Attenuation for CCIR P and Global H regions.

Clear Air and Cloud Effects

Cloud effects cannot be adequately modeled at the present time, but suffice it to say, clouds will reduce the link availability. In Table 1 the molecular attenuation for a tropical and a mid-latitude (July) atmospheric model at elevation angles of 10 and 20 degrees. For the same models it is assumed that the relative humidity is 80 % when it is raining. We see that for a link margin of 5 dB, when it is raining, about to rain, or extremely hot and humid, the molecular attenuation can be sufficiently large to make the link unavailable. This is may be a more important factor at mid-latitudes than in the tropics for a global system, since the elevation angles will be smaller. A system planner would like to incorporate a global non-precipitating attenuation model, which would give

global statistics of molecular and cloud attenuation, in his planning. The ACTS program will give some input to this need but unfortunately the information is not available today.

Table 1.
20 GHz Clear Air Attenuation

Atm. Model	Temp. (Surf) Kelvin	RH (Surf) Per cent	Attenuation (dB) 10 deg. elev.	Attenuation (dB) 20 deg. elev.
Tropical	300	75	4.3	2.2
Mid-Lat (July)	294	75	3.3	1.7

Table 2.
20 GHz Clear Air Attenuation (Raining)

Atm. Model	Temp. (Surf) Kelvin	RH (Surf) Per cent	Attenuation (dB) 10 deg. elev.	Attenuation (dB) 20 deg. elev.
Tropical	300	80	6.3	3.2
Mid-Lat (July)	294	80	5.5	2.8

To summarize, more attenuation data is needed for the proper design a global communication system, with small link margins, operating at 20 GHz. In particular, rain data in tropic regions and a global non-precipitating attenuation model are needed.